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On 10 August 1979 Dr K. A. Ferguson, Director of the CSIRO Institute of Animal and Food Sciences, announced that the CSIRO Executive had appointed Dr J. H. B. Christian as Chief of the Division of Food Research, following world-wide advertisement of the position.

After service in the RAAF and graduation in Agricultural Science from the University of Sydney, John Christian joined the Division of Food Preservation, as it then was, in 1951. Subsequently, in 1956, he was awarded the PhD degree from Cambridge University. With Dr W. J. Scott, Dr Christian carried out pioneering studies on the water requirements of microorganisms. This work provided basic information for understanding the keeping qualities of many foods and in particular for the modern technology of intermediate moisture foods.

In 1964 Dr Christian succeeded Dr Scott as Leader of the Microbiology Group; in 1967 he became Assistant Chief, and in 1971 Associate Chief of the Division of Food Research. In 1975 he was elected a Foundation Fellow of the Australian Academy of Technological Sciences.

Dr Christian's international reputation is attested by many invitations to lecture overseas and by appointment to five major international committees concerned with the microbiological safety and quality of foods — to three as an Australian delegate and to two (the International Commission on Microbiological Specifications for Foods and the WHO Expert Advisory Panel on Microbiological Aspects of Food Hygiene) as an independent expert. Since 1974 he has served as consultant to WHO on microbiological criteria for foods on six occasions, and was the first consultant appointed by WHO in this field.

Dr Christian has an extensive knowledge of the Australian food industry and its problems and many friends among its technical and management personnel who will wish him well in his appointment.

Recovery of waste activated sludge as an animal feed

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Over the past 10 years there has been an enormous increase in the importance placed on the quality and appearance of effluents discharged from Australian industries. As a consequence many industries have been forced either to install or to upgrade wastewater treatment facilities to meet required environmental standards. This trend is of particular importance to the meat industry since meat processing requires the use of very large volumes of water which are usually heavily polluted when they leave the plant.

The most common method of treating effluents in Australian abattoirs is based on the practice of lagooning, where the effluent from the abattoir passes through a series of anaerobic and aerobic lagoons. Usually, this is quite an efficient treatment method requiring both low capital and low maintenance cost. It suffers, however, from the disadvantage that it requires the use of large areas of land. This is a significant drawback when considering the case of larger metropolitan abattoirs where land costs may be high. Therefore, under these circumstances, alternative methods of wastewater treatment are being increasingly implemented.

Probably the most important of these methods is the activated sludge process. This is an aerobic treatment which has been in use for many years for domestic and industrial wastewaters, and it results in an effluent of very high quality. One of the major difficulties encountered with this method of treatment, however, is the disposal of the waste biological sludge that is produced by the treatment process. The cost of sludge disposal can comprise a very substantial percentage of the overall operating cost of a treatment plant, sometimes being as high as 40–50%.

One of the major reasons for the high disposal costs is the very high water content of the sludge. Waste activated sludge (WAS) consists essentially of a dilute slurry of microorganisms (mainly bacteria) and when discharged from the treatment system contains only 1–2% solids on a dry weight basis. Dewatering with the use of either industrial centrifuges or filters (see Fig. 1) yields a cake with a solids content of 10–15%, and at this concentration the sludge behaves as a gelatinous solid.

The usual method for disposal of the dewatered sludge is land dumping. This involves recurring labour and transport costs as well as the problem of finding a suitable disposal site close to the plant.

There is an obvious need for a cheaper and more acceptable form of disposal, and to this end a number of alternative methods have been suggested.

Before considering these methods it is useful to look at the basic composition of dried WAS. In Table 1 the results of more than 20 analyses of waste activated sludges from Australian abattoirs are listed as well as data from other workers.

Table 1. Composition of waste activated sludge

	Dry weight (%)	
	Average	Range
Total nitrogen	6.4	5.5–7.3
Crude protein (% N x 6.25)	40	35–45
Total phosphorus	1.3	1.1–1.8
Fat (ether extractable)	14	2–27
Fibre	12	7–20
Residue on ignition	16	12–22
Vitamin B_{12}[A] (μg/g)	7	2–12

[A]Dougherty and McNary 1958.

There are several features of interest in Table 1. The first is the reasonably high content of crude protein. Most samples analysed contained approximately 40% crude protein. Values lower than this were usually associated with a high fat content in the sludge (>10%). Such samples were obtained from effluent treatment systems in which the fat recovery unit was operating at low efficiency.

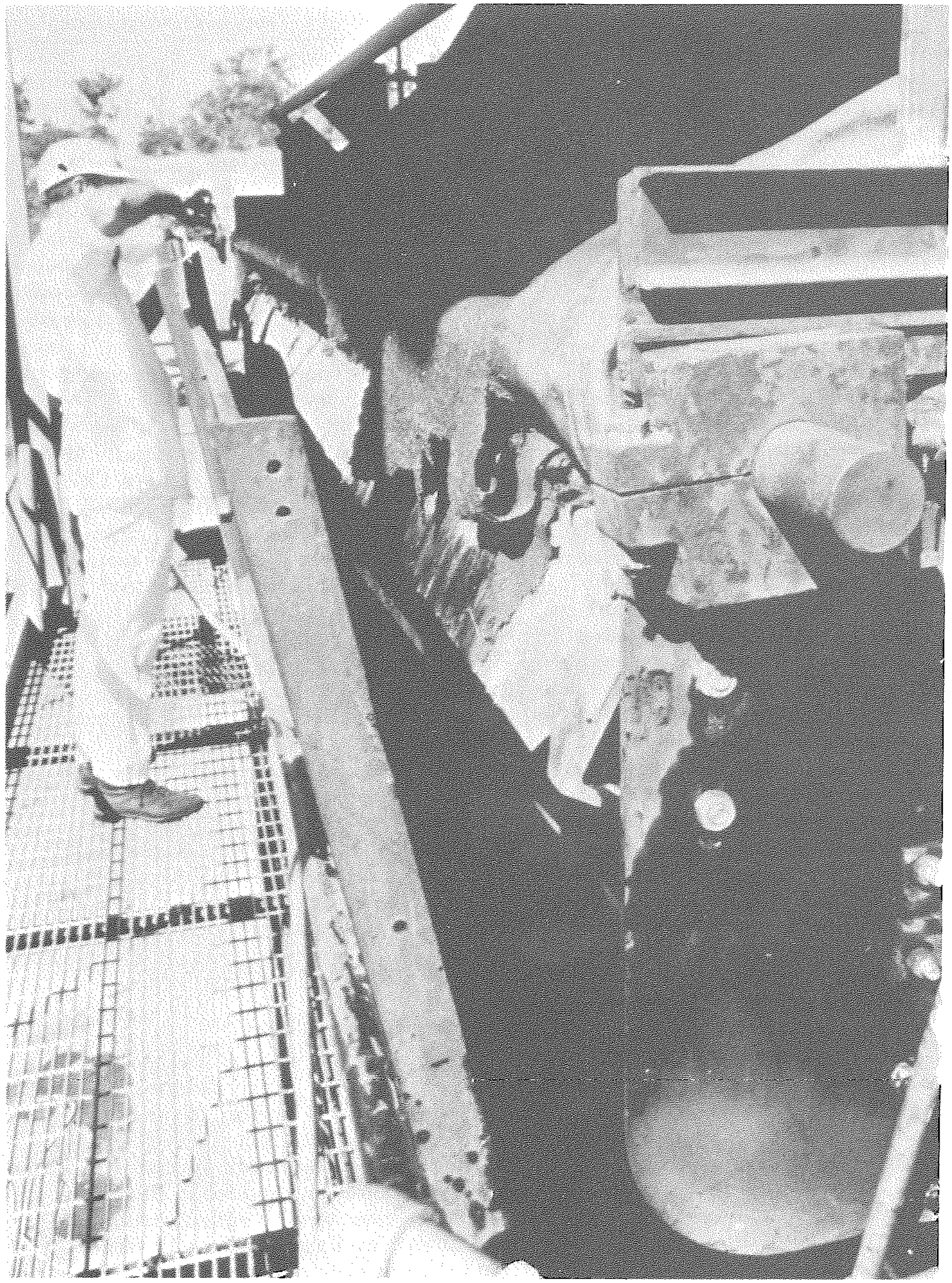

Fig. 1. Dewatered waste activated sludge coming from a rotary vacuum filter at a meat works effluent plant.

The reasonably high crude protein content suggests that WAS might have some value as an animal feed supplement. Dewatered sludge destined for this purpose would first have to be heat-dried to eliminate potential problems due to pathogenic organisms and to allow the material to be stored for reasonable periods of time.

The high organic nitrogen content also suggests the possible use of WAS as a soil conditioner and fertilizer. Biological sludges have been used extensively for this purpose in the U.S.A., being applied wet or dry. The use of biological sludges in this way is not as widespread in Australia, although anaerobically-digested sludges from sewage works are being increasingly used as a component of organic fertilizers. The economic return, however, is relatively low at the present time.

It has also been suggested that WAS might be used as a source of specific chemicals. In particular, interest has been expressed in the possible extraction of Vitamin B_{12} (Forster 1973). At the moment, however, the economics of such a process are doubtful and no commercial applications have been attempted.

We believe that use of the WAS dried solids as an animal feed supplement is most promising.

Activated sludge as a feed material

Interest in the possible use of dried WAS as an animal feed was first aroused during the 1950s. The investigations conducted about this time (Hackler *et al.* 1957; Hurwitz 1957) were mainly concerned with the possible use of activated sludges arising from the treatment of domestic sewage. Whilst such sludges initially showed considerable promise as feed materials, it was subsequently found that the dried solids contained substantial concentrations of toxic heavy metals such as cadmium and lead, presumably as a result of industrial contamination (Sommers 1977). The presence of high concentrations of these metals in sewage sludges has rendered the sludges unacceptable as feed materials and has also curtailed their application as fertilizers.

Sludges arising from the treatment of food industry wastes, however, should be relatively free from such contamination. We have analysed WAS from two Australian abattoirs and the results are presented in Table 2, together with reported concentrations of metals in WAS from sewage works.

Table 2. Metal concentrations in waste activated sludges

Element	Abattoir (arithmetic mean, 20 samples)	Sewage works (arithmetic mean; Sommers 1977).
	(ppm on dry weight basis)	
Calcium	9900	33 000
Iron	4340	11 000
Zinc	220	2170
Copper	70	940
Manganese	110[A]	420
Cobalt	3	—
Chromium	60[A]	1270
Lead	16	720
Cadmium	0.25	135

[A]Two samples only

In general the concentrations of metals in WAS from abattoirs are substantially lower than those found in sewage sludges. Of particular interest are the concentrations of the toxic heavy metals, lead and cadmium. The concentrations of both these metals appear to be within levels considered acceptable in feed rations (Fritz 1973). Current guidelines, however, are usually based on the toxicity of the particular metal to a specific animal and do not necessarily give any indication of potential hazards arising from the accumulation of such metals in animal tissue. As a large proportion of conventional meat meal is used in the production of poultry for human consumption, it is clear that direct tissue analyses of animals fed on WAS are desirable, in order to establish that no risk to human health can arise. Such analyses are planned as part of a program of feeding trials to be carried out in the near future.

Amino acid composition

The nutritional value of the protein fraction of feeds is largely determined by the concentration and balance of the amino acids of which the protein is composed. Of particular importance are the essential amino acids that must be provided in the diet at levels sufficient to meet nutritional needs.

The results of amino acid analyses of activated sludge are shown in Table 3, together with similar data from New Zealand for commercial meat meals.

Table 3. Amino acid composition of waste activated sludge and meat meal

Amino acid (g/16gN on dry weight basis)	Abattoir sludge		Meat meal[A]
Alanine	7.0	7.6	–
Glycine	4.6	13.0	–
Valine	3.8	3.9	3.6–5.2
Threonine	4.2	4.8	3.1–4.4
Serine	3.3	4.9	–
Leucine	5.8	6.1	5.5–7.9
Isoleucine	2.5	2.5	2.6–4.1
Proline	3.2	3.3	–
Hydroxyproline	0.4	0.3	–
Methionine	n.d.[B]	n.d.	0.8–1.5
Aspartic acid	8.5	8.9	–
Phenylalanine	3.4	3.7	3.1–4.2
Glutamic acid	8.9	8.5	–
Lysine	3.9	4.3	4.9–6.8
Tyrosine	2.1	2.5	2.3–3.2
Arginine	3.4	3.7	7.0–8.2
Histidine	0.9	0.7	1.3–1.8
Cystine	3.6	n.d.	0.1–0.4
TOTAL	69.5	78.7	

[A]Lambden and Averill, personal communication.
[B]n.d.: not detected.

The analyses indicate that all amino acids essential for normal nutritional requirements are present in WAS in reasonable quantities with the exception of methionine and possibly cystine.

Similar results have been obtained in New Zealand (Heddle, personal communication) using WAS generated from meatworks effluent in a laboratory experiment. It would appear that the amino acid composition of abattoir WAS is reasonably constant, and apart from the possible deficiencies in sulphur amino acids, is quite adequate for avian and mammalian nutrition.

Feeding trials

In order to assess the nutritional value of WAS, controlled feeding trials were carried out (by Dr G. R. Skurray of Hawkesbury Agricultural College) with a sample of dried WAS from a local abattoir. Analyses showed the sample contained 21.3% crude protein* and 25.6% fat. In the feeding trials the dried WAS replaced meat meal and wheat in the diet of seven-day-old Leghorn x Black Australorp chicks (Fig. 2).

Three replicates of ten chicks were fed on each of three diets, the details of which are given in Table 4. Details of the method and statistical analysis have been presented elsewhere (Skurray and Cumming 1974).

It can be seen from Table 4 that the inclusion of up to 20% by weight of dried WAS in the diet had no significant effect on the average weight gains by the chicks. At the maximum concentration of 20%, the sludge replaced approximately one quarter of the total crude protein in the diet. This result clearly shows that dried WAS has satisfactory nutritional value and that the material is acceptable to the digestive systems of the chicks. However, the feed intake of the chicks was slightly greater in the case of the group on the 20% WAS diet, resulting in a slightly lower value for the feed conversion efficiency. No adverse effects in the form of either mortality or disease were observed in the chicks on the WAS diets throughout the course of the feeding trials.

Feeding trials with WAS produced from fruit cannery waste have also been successful (Esvelt *et al.* 1976). In this study, dewatered sludge was added to the rations of cattle at levels of up to 9% with no decrease in weight gain. Carcass quality of cattle on the maximum sludge diet was reported to be equivalent to that of the control group and carcass analyses showed metal and pesticide residues to be within acceptable limits.

These findings substantiate the suggestion that WAS may be used effectively as an animal feed supplement. Probably the major difficulty to be overcome in the processing of WAS to a form acceptable as stockfeed is the

*The unusually low crude protein content of this sample may have been due to decomposition occurring during the slow drying of the dewatered sludge at elevated temperatures (~90 °C).

Table 4. Chick feeding trials

Percentage components of diets	Diets 1	2	3
Meat meal	20	17.5	15
Wheat	75	67.5	60
Skim milk	5	5	5
Dried WAS	0	10	20
Results			
Average weight gain (g/day)	7.54	7.38	7.52
Average intake (g/day)	19.9	21.2	23.4
Food conversion efficiency	0.38	0.35	0.32

high cost of drying of the dewatered solids. Even after dewatering, the cake still contains 85–90% moisture, so that large volumes of water have to be removed to produce a dry material. Fortunately, abattoirs are well placed in terms of the facilities required to perform such an operation. Dry rendering equipment normally used for the production of meat meals might well be used for the drying of dewatered activated sludge.

Fig. 2. Feeding trials with chicks on WAS diets.

We have performed a preliminary costing of the overall production process assuming that the sludge would be dry-rendered in conjunction with waste offal material. The results of this analysis show that reasonable profits should be achieved, particularly if waste heat is recovered from vent gases from the cookers.

In the near future it is planned to conduct full-scale dewatering and drying trials with the cooperation of local abattoirs. Large-scale feeding trials involving both chicks and pigs are also envisaged. The results of such tests should give a better idea of the economic feasibility of the process.

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Composition of some Australian table margarines

It has been drawn to our attention that the fat content values obtained for some Australian table margarines and recently quoted in an article of the above title (*CSIRO Food Res. Q.* 1979, **31**, 38–43) may not be absolutely accurate. In obtaining these values we chose to use the direct extraction method of Bligh and Dyer (1959), which has been used for many years in our laboratory as one of the most versatile methods for direct extraction of fat from a variety of materials. There are indications, however, that the method is subject to slight errors when compounds of very high fat content such as margarines are analysed in this way. The reasons for these discrepancies are being investigated and a revised table will be published in a later edition of the Quarterly.

Bligh, E. G., and Dyer, W. J. (1959). A rapid method for total lipid extraction and purification. *Can. J. Biochem. Physiol.* **37**, 911–17.

Handling and storing fresh fruit and vegetables in the home

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Introduction

Living produce

A basic understanding of the nature of fresh fruit and vegetables will help greatly in getting the best value for money or the best reward for time, effort and money spent in producing a crop in the home garden.

Fruit and vegetables are not dead foods like bread and meat but are living things that breathe much as we do, and they can be suffocated by being deprived of oxygen if enclosed in a sealed, airtight container. After harvest they are cut off from continued replenishment of nutrients and essential water. These losses are not made up, so the produce is now perishable and at the mercy of the environment; deterioration has commenced.

Unlike humans the respiration and other life processes of fruits and vegetables are directly dependent on the temperature. The higher the temperature the more rapid are these processes and thus the more quickly fruits and vegetables will ripen and deteriorate. The lower the temperature the slower these life processes and the longer will fruit and vegetables keep after harvest. Nevertheless, if they are to be kept in the fresh state, the temperature must not be less than *their* freezing points, which are just below the freezing point (0 °C) of pure water. For most perishable produce the lowest safe temperature for storage is therefore 0 °C.

However, some fruits and vegetables are chilling sensitive, which means they are damaged by prolonged exposure to temperatures even as low as 10 °C. The severity of cold injury depends on the duration of exposure as well as on the temperature. Short periods below 10 °C may be tolerated without permanent damage. Bananas and most tropical fruits, potatoes, sweet potatoes, pumpkins and marrows, squashes, cucumbers and zucchinis, tomatoes and capsicums are chilling sensitive. Bananas are very sensitive and the skin will rapidly blacken in the domestic refrigerator, where the temperature is usually 5-7 °C.

Water loss and wilting

Fresh fruit and vegetables have a high water content and this essential water is rapidly lost by evaporation from their surfaces. The main effects of water loss are wilting and shrivelling. Water loss is rapid in warm dry air and is increased by excessive air movement. It is also very rapid from leafy vegetables that have a very large surface area compared to their volume, and from small items with a tender skin such as green beans, zucchinis and berry fruits. Fruits such as citrus and some apples that have a waxy skin, lose water and shrivel more slowly. Wilting can be retarded by wrapping or packaging in thin plastic film or waxed paper or even, to a lesser extent, by wrapping in newspaper. Keeping the produce in plastic bags is very effective but the bags should be perforated to avoid suffocation of the fruit and vegetables.

Ripening

During ripening, fruits soften, becoming luscious and juicy, the characteristic sweetness and flavour develop, and the green colour of the unripe fruit changes to the yellow, red or purple colours of ripe fruits.

Many fruits, including tomatoes, which are true fruits, are harvested unripe to permit safe handling, transport and marketing. However, so that they can later ripen normally and develop good eating quality, they must be mature when harvested. Immature fruit will not ripen to good quality and it shrivels faster than mature fruit.

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Bananas, which must be harvested hard and green, are an exception as even half-green fruit will ripen to acceptable quality. All these fruits commonly require to be ripened or to complete their ripening after being bought by the consumer. The best temperature for the ripening of all fruits is about 20°C. At appreciably higher or lower temperatures quality suffers, and most fruits will not ripen at all at temperatures below 10°C.

The ripening process is complex and not yet fully understood. However, it has long been known that natural ripening can be induced by exposing fruit to very low concentrations of the gas ethylene. This is the method used in the commercial ripening of bananas, and they will not ripen quickly and uniformly without gassing. Ethylene is produced naturally by all fruits as an essential controlling part of the ripening process.

Careful handling

Perishable produce must always be handled carefully. Rough handling causes bruises, cuts, scratches and abrasions, which are all breaks in the natural protective covering — the skin. These injuries not only spoil the appearance and make the damaged parts inedible, but also hasten ripening and deterioration. The more serious injuries result in infection and so greatly increase the risk of total loss by rotting. It follows that only sound, clean produce, free from bruising and other damage can be successfully stored without losses.

Rotting

The spores of moulds and bacteria that cause rotting of fruit and vegetables are present on the produce and often in the air and on any surface where dust can settle. These spores can readily infect fruits and vegetables through breaks in the skin, and start decay. Some can even infect through the sound skin if surface moisture is present for germination. Most decay-producing organisms will grow only slowly, if at all, at low temperatures. Most grow best and cause rotting most rapidly at temperatures of 20–25°C. Therefore, in addition to careful handling and cleanliness, a main defence against losses by decay is to 'cool it'.

For some crops there are chemical treatments that will prevent decay. Nowadays almost all citrus fruit and bananas, and many stone fruits, are treated in the packing house with an approved fungicide to kill moulds. The use of chemicals for the postharvest control of wastage in perishable produce has followed extensive research and presents little risk to consumers. Without these treatments losses during storage and marketing, and in the home from such diseases as green mould in citrus, brown rot in stone fruits and internal 'squirter' disease in bananas could, at times, be catastrophic, as indeed they have been in the past.

How perishable?

It is obvious that, even at ordinary temperatures, some kinds of fruit and vegetables keep much better than others. Strawberries, ripe bananas, peaches, tomatoes, green peas and zucchinis will keep for only a day or two. Others, like potatoes, onions and pumpkins — the so-called 'hard vegetables' — will keep for weeks. It is important to understand this wide range of perishability and keeping quality. The Appendix lists most kinds of produce according to their perishability and indicates how long they can reasonably be expected to keep in good condition at the temperatures most suitable for long storage.

Where shall I keep them?

It is often said, particularly of unripe fruit, that 'they keep better in the dark'. There is some practical basis for this common belief, as a dark place in the house is usually a cool place.

However, light itself is not a factor except with potatoes. Potatoes *must* be kept in the dark to avoid 'greening', which is associated with the production of a poisonous alkaloid, solanin.

In warm weather, perishable produce should be kept in the coolest place available. For fruits and vegetables not subject to chilling injury the best place is in the domestic refrigerator, but not, of course in the freezer section. Certainly, for apples, pears, stone fruits and strawberries, the best place is in the refrigerator. Because the air in a domestic refrigerator is rather dry, most fruit and vegetables should be kept covered in the crisper or in a plastic bag with a few holes in it. It is better to cool them *before* putting them in the bag or covered container. If warm produce is placed in plastic bags and then put into the refrigerator, moisture condenses on the inside of the bag (fogging) and encourages rotting.

In warm weather, when many of the more perishable kinds are in season, and when a refrigerator is not available, or the items are sensitive to chilling, keeping perishable produce is much more of a problem than in the cooler and cold seasons. At this time, the coolest place outside the refrigerator will be under the house, if the space there is enclosed. The reason for this is that in summer ground temperatures are much lower than air temperatures, whereas in winter the reverse is true. Under the house is, therefore, a good place to keep perishables in warm weather, provided that they are protected from attack by rats or mice.

Indoors, a walk-in pantry or large cupboard can be kept cool if there is a space under the floor, by cutting a large hole in the floor and another one in the ceiling. A current of cool air will then be drawn up from under the house through the pantry or cupboard and out the top, provided that the door and any window are tightly closed. The holes, say 25 by 25 cm for a pantry, should be covered with fly wire which, of course, should be kept clean.

The produce should be stored in such a way that it is not crowded and there should be good circulation of air around each package or around large items such as cabbages and pumpkins. Overcrowding is particularly bad in a refrigerator, since it results in poor air circulation and, therefore, poor cooling of the contents. It is worthwhile to wrap each piece of fruit, or tomato or cabbage or cauliflower, or small units of produce such as peas, beans, brussels sprouts and broccoli in paper, preferably waxed paper, or thin plastic sheeting. This is to reduce shrivelling, especially if the air is dry, and to isolate any piece that may go bad, and so reduce the risk of sound produce becoming affected. To reduce shrivelling it is also useful to line the box or basket containing the produce with thin plastic film or waxed paper, or with several thicknesses of newspaper.

Evaporative cooling

Evaporation of water requires considerable heat. Thus when no heat is applied, evaporation of water produces a considerable cooling effect and the faster the evaporation the greater is the cooling. This is how evaporative coolers work. In hot, dry climates, when the rate of evaporation is also high, these machines can provide cool and moist air for storing fresh fruit and vegetables as well as other perishables.

An evaporative cooler can be used to cool a small room, or a drip safe ('Coolgardie safe') can be constructed. A drip safe, which can be of any size, has its walls and door of hessian (burlap) or towelling, stretched over the frame of the structure, and perhaps protected with wire netting. The top is solid to support a full-size tray of water. The sides are kept wet by a series of wicks made of towelling, or similar material, hanging down from the tray, which should be 6–10 cm deep, and kept filled with clean water. Evaporation of water from the large wetted surface of the sides effectively cools the safe and its contents to close to the wet bulb temperature of the ambient air. The safe should be placed in a breeze-way for maximum cooling.

On a larger scale, a whole walk-in, evaporatively cooled room can be constructed. The spaces between wall studs are packed with washed and graded coke or charcoal and held in place with fine mesh galvanized wire netting (chicken wire). By some convenient means, such as a length of sprinkler hose around the top, water is slowly trickled down the walls to keep them just fully wetted. An exhaust fan in the centre of the ceiling will ensure adequate movement of air through the walls and circulation of the cooled air through the produce. Alternatively, only one wall can be a wet wall, in which case the exhaust fan should be high on the opposite wall. The room should be under cover, protected from the sun and rain, but in a place open to any breezes.

Fruits

Apples

Good quality apples are freely available almost the year round — during the harvest season from February to April, later from ordinary cool storage, and still later from controlled atmosphere storage ('C.A.') until the end of the year and well into January. There is little need to store apples for long periods in the home unless case lots are bought cheaply or they are home grown. Depending on the variety and degree of ripeness they will keep for a long time, even several weeks, in the refrigerator. Early varieties, e.g. Gravenstein, and Jonathan and Delicious, which ripen quickly, are best kept in the refrigerator to preserve them in good condition, unless they are to be used within a few days. On the sideboard is *not* a good place to keep apples or indeed any fruit.

For home storage Granny Smith is the best keeper and will remain sound for a long time if kept in a cellar or other cool place, especially in colder climates.

Maturity is the best guide to eating quality when buying apples. If the base colour of the skin is a definite green they will be immature, woody, sour and tasteless and will not improve much on keeping. If the base colour of the skin is distinctly yellow the fruit may be very good for immediate eating but will be no good for keeping. A yellow-green to green-yellow ground colour indicates a full mature, but not over-mature, apple and if it is also sound, clean and free from bruising it will keep well. The amount of red on the skin is not a good guide to maturity, but dull red indicates immaturity and may be the only external guide to the maturity of fully red fruits such as the common red sorts of Jonathan and Delicious.

Large apples, especially large Jonathans, do not keep well, even in the refrigerator, as they are more liable to flesh breakdown than smaller fruit. Unless very cheap, large Jonathans are not a good buy at any time.

Pears

The harvesting season for pears is from January to the end of March. The main early variety is Williams which is very good eating but rapidly ripens and becomes over-ripe in warm weather. It is a poor keeper, even in cool storage, and does not ripen well at temperatures much above or below 20 °C. Good quality later varieties of pears, mainly Packham's Triumph, are available from cool storage until late in the year.

Pears will not ripen well on the tree and must be harvested when hard green, but full size, especially when they are to be cool stored. To ripen normally with good eating quality, pears must be ripened at a temperature close to 20 °C. Fruit that is bought hard and green can be held in the refrigerator for fairly long periods and brought out to ripen as required. Pears which are bought in the ripe, or partly ripe, condition can be kept in the refrigerator for no longer than a few days.

Pears that have been kept too long under refrigeration will become more or less yellow without softening, as will fruit left too long on the tree. Such fruit has lost its ability to ripen normally and will never be good to eat. Therefore, when buying pears, never buy fruit that is both hard and yellowing or which shows a brown scalding of the skin (another sign of overstorage). Pears that are deep green may also not be good buying as this usually indicates immaturity, and immature fruit ripens to poor quality and shrivels easily.

Later maturing varieties of pears — Packham's Triumph, Winter Cole and Winter Nelis — if still hard and green, will keep for a considerable time in a cool place, and if the temperature is above 7 °C, will ripen slowly but not to best quality unless transferred to a temperature of about 20 °C. To reduce shrivelling, the fruit should be wrapped or the containers lined.

Citrus fruits

Oranges, lemons, mandarins and grapefruit are very subject to attack by green and blue moulds and other rots, especially if over-mature or harvested in wet weather. However, nowadays, most citrus fruits are washed, treated with a special fungicide and waxed before being marketed. Therefore they can be expected to keep satisfactorily, retaining their appearance and flavour for 2–3 weeks at room temperatures, unless the weather is very hot. Lemons and grapefruit should keep a lot longer than oranges or mandarins, and in fact they may improve in juiciness and taste. The skin becomes deeper yellow in colour and thinner, and the juiciness increases during 'curing'. Except for this curing of lemons, citrus fruits keep best in the refrigerator where the temperature is 5–7 °C. Outside the refrigerator they should be kept in the coolest place available.

Unlike pears and bananas, citrus fruits do not ripen after harvest but they gradually improve in palatability as they mature on the tree, becoming sweeter and more flavoursome until they finally become over-mature and insipid. Apart from appearance, the main quality factors are juiciness, sweetness and flavour. The colour of the skin is not necessarily a good guide to internal quality. Late in the season the skin of Valencia oranges commonly 'regreens', but the internal quality may still be good, and citrus fruits grown in more tropical climates may remain greenish in colour, although they are fully mature. Better guides to quality are skin texture and weight; those with a coarse, pebbly skin, and which are light in weight, are likely to have a low content of poor quality juice. Therefore, consumers should look for heavy fruit with a fine skin, and avoid greenish oranges and mandarins early in the season as they may be sour. In general, smaller fruit will be juicier than larger fruit.

The storage of home grown, or freshly picked citrus fruit, can be improved by treatment. For home storage the fruit should be dipped as soon as possible and for half a minute in the fungicides Benlate(®)* or Bavistan(®)* at the recommended strengths in water to which a little household detergent has been added to make sure all fruits are fully wetted. After being spread out to dry on netting or something equivalent, each fruit should be covered with a *very thin* film of petroleum jelly (e.g. Vaseline(®)**) by rubbing a little on the hands and then wiping it over the fruit and almost wiping it off again. This will reduce shrivelling of the fruit considerably, but if the coating is too thick the fruit will suffocate and develop off-flavours.

After treatment with the fungicide the fruit could, instead, be waxed by dipping in one of the water-base liquid floor polishes (which are similar in composition to the wax emulsions used commercially on citrus) diluted with an equal volume of water, then drained and dried.

Bananas

To ensure safe transport from the more tropical areas where they are grown, bananas are harvested while still hard and green. They are then ripened or partly ripened by exposure to ethylene under carefully controlled conditions in special ripening rooms at the markets. Apart from bruising, the eating quality of bananas depends almost entirely on the temperature at which they are ripened.

Best quality is obtained by ripening at temperatures between 18° and 22°C. The skin of the ripe fruit will then be clear, bright yellow but will still be firm, and the pulp will be soft but not mushy, sweet and full of flavour. A fully ripe fruit is commonly flecked with numerous dark spots that are actually minor infections of the anthracnose fungus. If the infection is severe, or if the fruit is bruised, or has been chilled, rotting may develop. At temperatures much above 25°C the skin remains greenish, the pulp rapidly becomes mushy and the flavour is poor. At temperatures that are much lower than 18°C, ripening is also poor, the skin colour is dull and greyish and the pulp remains hard and dry with little flavour. It is important to understand these effects of temperature on ripening because bananas are often retailed only partly ripened so that the temperatures after they are removed from the ripening rooms are critical. In summer they are often too high and in winter too low so that there is a much better chance of eating well-ripened fruit in the late spring or early autumn when temperatures are around 20°C. Fruit may in fact have been damaged by unfavourable temperatures before the shopper sees it.

Bananas are very sensitive to chilling: if put in the refrigerator the skin rapidly blackens and, if green bananas are put in the refrigerator, they quickly lose their capacity to ripen to good quality even at favourable temperatures. If the fruit is ripe, although the skin blackens in the refrigerator, the pulp will remain in good condition for 2 or 3 days. Bananas are best kept in a cool place unless further ripening is required and, if possible, temperatures above 25°C should be avoided at all times. Unripe fruit will keep much longer if sealed in a plastic bag, but it must be removed for ripening. Blackening of the skin as well as damage to the pulp can also be caused by bruising and by fungal infections. Most of these infections (e.g. blackend and anthracnose) can be prevented by proper treatment of the fruit with an approved fungicide (Benlate(®) or Bavistan(®)) after harvest, but some growers still neglect to do this.

Blackend — a rot at the stem end — can be serious in bananas packed in the old way as 'singles' unless treated properly. Fruit packed and sold in 'hands' or 'clusters' will keep better.

Big, fat and over-mature bananas are not usually the best quality fruit — it is better to buy bananas of moderate size that are still slightly angular in shape. Bananas are available all the year, supplies being low in winter but often reach glut proportions in late spring or summer. Once they reach a certain stage of maturity, bananas must be harvested, otherwise ripening starts on the plant and the fruit is then unfit for normal

* Benlate and Bavistan are registered trade names of E.I. du Pont de Nemours & Co.

** Vaseline is a registered trade name of Chesebrough-Ponds Inc.

marketing. Bananas are unusual as even half-grown fruit will ripen quite well once it is removed from the plant.

Pineapples

Pineapples are obtainable all the year round; in summer they are more plentiful, sweeter and generally of better quality than in winter. In late winter and early spring pineapples are often affected with 'blackheart', a dark brown discoloration of the flesh that is a chilling injury following damage by cold either in the field or after harvest; the flavour is also affected. Pineapples do not improve or ripen after harvest. They can be held for a few days at ordinary temperatures and longer under cooler conditions but may develop chilling injury at temperatures below about 15 °C. Whole or cut up fruit will keep for several days in the refrigerator and prepared fruit freezes well, even without added sugar or syrup.

The colour of the skin is not a reliable guide to the maturity of pineapples. Fruit that is ready to eat will be yellow in winter, but in summer may still be distinctly greenish. If the inner leaves can easily be pulled from the top, the fruit is usually mature. When buying pineapples, avoid fruit with water-soaked patches, obvious bruising or a beery smell, indicating marked over-ripeness.

Papaws

Papaws will ripen after harvest but should show some yellowing of the skin to be sufficiently mature to pick. However, particularly in the spring, fruit may be well-coloured but somewhat hard and flavourless and such fruit usually does not improve much on keeping. When ripe, a good quality papaw will be soft and have a noticeable papaw aroma. Because quality is variable, to avoid disappointment it is best to look for such fruit when buying.

Papaws are very subject to anthracnose ripe rots. These are not serious unless the rot spots, which develop as the fruit ripens, are large. Unripe fruit will keep in the refrigerator for up to 2 weeks, or somewhat less in a cool place, and then can be ripened in a warm place. However, it is better to buy a selected ripe fruit and to use it without delay as in this way there will be much less risk of getting a poor quality fruit. Ripe fruit will keep for a few days at ordinary temperatures and somewhat longer in the refrigerator, either whole or prepared for eating.

Avocados

Avocados are unusual in that they will not ripen at all on the tree and will only soften and ripen after they are picked. During ripening the skin does not become yellow, but remains green or changes to a dark purple, according to the variety. Unripe fruit will keep for up to 3 weeks in the refrigerator and somewhat less in a cool place and then can be ripened in a warm place. As soon as they become soft they should be eaten as they deteriorate rapidly if kept longer. Ripe fruit will keep for several days in the refrigerator if necessary and the pulp freezes well.

Mangoes

Although they will ripen after harvest, mangoes should be yellowish when purchased to be of good quality when finally ripe. Unripe fruit can be kept for 7–10 days in the refrigerator and will still ripen well after removal, but ripe fruit will keep for only 3–4 days. At ordinary warm temperatures mangoes will ripen rapidly. Because they are liable to chilling injury, the best temperature to keep unripe mangoes is 10–12 °C but this temperature is usually not available in the home during the summer when mangoes are in season.

Tropical fruit in general

Although ripe fruit can be kept in the refrigerator for a few days, some flavour is lost and unripe fruit will develop chilling injury if kept too long at refrigerator temperatures. Therefore, in general, the safest storage temperature is 10–12 °C. At this, and higher ordinary temperatures, unripe bananas, papaws, mangoes and avocadoes can be kept in sealed plastic bags (of ordinary thin polyethylene film) about twice as long as when freely exposed, but they should be removed at the first sign of ripening.

Passionfruit

Passionfruit do not keep well but their life at ordinary temperatures can be doubled by treating with a fungicide and petroleum jelly or wax, as outlined for citrus. In the warmer part of the refrigerator they will keep for up to 2 weeks, but they should be protected from drying to avoid excessive shrivelling. If kept longer they will chill, the skin will become soft and papery and rots will develop. The frozen pulp, preferably with added sugar, keeps well.

Passionfruit do not ripen after harvest. Mature, good quality fruit will be either purple, red or yellow depending on the variety, with no green showing and will feel heavy in the hand. Light weight fruit will not be well filled with good juicy pulp.

Grapes

Grapes do not mature further or ripen after harvest so they should be mature and sweet when purchased. Definite green coloration in white grapes and excessive red in black grapes suggest immaturity.

Apart from maturity the main quality requirements are uniformly large berry size and freshness. Fresh grapes will have firm, fresh looking, green to golden bunch stems, firm, bright berries and no loose, dropped, split or mouldy berries. Bunches with dry, discoloured stems and soft or dropped berries are aged, but if sound, are good to eat but not to keep.

To keep grapes fresh they should be promptly cooled in the refrigerator, put into plastic bags and returned to the refrigerator where they should last for up to 3 weeks or longer, depending on the variety and initial soundness. The seedless Sultana, an early variety now popular as a table grape, does not keep as well as later varieties. As a rule, tight bunches do not keep as well as loose bunches. At ordinary temperatures grapes will keep only for a week or two. Because grape stems dry out so rapidly, it is worth while keeping grapes in plastic bags wherever they are being held.

Stone fruit

Peaches, nectarines, apricots, plums and cherries are very perishable and, as they also come in the warm weather, they ripen and deteriorate rapidly at ordinary temperatures. It is, therefore, generally best to buy small quantities and eat them as they ripen. Peaches, nectarines, plums and apricots ripen well after harvest but must be mature when picked. Mature fruit will show no definite green in the skin, will show slight softening at the suture or base under light finger pressure and will be full and rounded in shape.

Cherries do not ripen after harvest, light coloured fruit in dark coloured varieties is generally immature. Good quality stone fruit will also be firm, bright and free from bruising.

Unripe fruit can be kept in the refrigerator for 1 to 4 weeks, depending on kind and variety, and then ripened. Ripe peaches, apricots and nectarines can be kept for 2 or 3 days in the refrigerator, where cherries will keep for up to 2 weeks. Brown rot, which has been a major cause of loss in stone fruits can be well controlled by preharvest sprays and a postharvest dip with the effective fungicides now available.

Berry fruits

All berry fruits, such as strawberries and raspberries, are highly perishable and, if not consumed soon after purchasing, should be placed in the refrigerator where they will keep for up to several days if protected from drying out after cooling. For top quality, berry fruits should be highly coloured, firm and bright, free from any sign of mould or juice (indicating damaged berries) and free from small, misshapen or partly coloured berries. Berry fruits freeze well and are usually packed for freezing with dry sugar.

Persimmons

These are interesting fruits because, if picked while still quite hard and showing only a trace of colour and kept in a cool place (10–12°C is ideal), they will keep for a month or more, ripening slowly. Ripe fruit can be kept in the refrigerator for several days and the pulp freezes well. Unripe fruit can be ripened quickly by holding a dozen or so fruits with two or three ripe apples in a sealed plastic bag for 2 to 3 days.

Melons

Water melons must be ripe, with well-coloured, very juicy and sweet flesh when picked as they do not ripen after harvest. They are sensitive to chilling but can be kept in the refrigerator for up to two weeks.

Rock melons (cantaloupes) will ripen further after harvest but to be of best quality must be well matured when picked. On picking, a fully mature melon will break cleanly from the stem leaving a complete stem scar on the fruit ('full slip' stage). If picked earlier than the 'half slip' stage (only half a clean stem scar) the melon will be immature and of poor quality when ripe. Like water melons, ripe rock melons will keep only for a few days at ordinary temperatures. They will keep for 1 to 3 weeks in a cool place depending on the variety and the degree of ripeness, and ripe melons will keep for a week in the fridge.

Honey dews and casabas are later maturing, better keeping melons which last up to 4 weeks in a cool place. For good quality when ripe, they should not be picked earlier than the 'half slip' stage. At temperatures between 10° and 20°C they will ripen slowly to acceptable quality but, like rock melons, ripen best at 20° to 25°C.

Honey dews are sometimes difficult to ripen. They can be induced to ripen by placing them in a plastic bag with two or three ripe apples, sealing the bag and holding them this way for 2 or 3 days.

Vegetables

Very perishable vegetables

Many vegetables are very perishable and will keep for only a few days to no more than 3 weeks under the best conditions of storage. Most, including lettuce, silverbeet, spinach, broccoli, brussels sprouts, chinese cabbage, rhubarb, asparagus, green peas, sweet corn and radishes are not sensitive to cold and can be safely kept in the refrigerator for up to 2 weeks.

Those that are sensitive to chilling and keep best at 7–10°C include green beans, cucumbers, coloured tomatoes, capsicums and zucchinis. They can be kept in the domestic refrigerator but generally for no longer than a week. If kept too long in the refrigerator beans develop a streaky brown stain and/or discoloured sunken spots; cucumbers develop sunken, water-soaked spots and patches that often become slimy, the flesh later breaks down and the whole fruit collapses and rots; tomatoes become very soft, develop rot spots and lose flavour.

All of these vegetables, especially the very leafy kinds because of their very large surface area from which water evaporates, wilt rapidly. Unless used quickly they should be promptly placed in the refrigerator and as soon as they have cooled they should be put into the crisper, some other covered container, or vented plastic bags for further keeping. To avoid rotting they should be fairly dry when bagged.

If the refrigerator is not available, leafy kinds, rhubarb and broccoli can be kept satisfactorily for a few days in a cool place if held with the freshly cut stems in water. Asparagus, peas, sweet corn and zucchinis rapidly lose quality unless cooled promptly. Under warm conditions asparagus spears continue to grow and toughen, peas and sweet corn rapidly toughen and lose their sweetness; tomatoes and cucumbers, being true fruits, rapidly ripen and become over-ripe. Zucchinis are very immature true fruits and need special care; they should be cooled quickly and placed in plastic bags to prevent rapid aging and wilting and should not be kept in the refrigerator for more than a week.

Cabbages

Cabbages keep best at 0°C but will keep for 2 to several weeks in the refrigerator depending on whether the variety is an early or late maturing kind. At higher, but still cool, temperatures most kinds will keep for a few weeks. Cabbages for storage should be only lightly trimmed as, during storage, the outer leaves wilt and become yellowish and must then be removed. To reduce wilting it is an advantage to wrap each head in thin plastic film, waxed paper or even in newspaper.

Celery

Celery has a short life at ordinary temperatures but will keep for 2 to 3 weeks in the refrigerator. If kept longer the stalks develop brown streaks and may become pithy and spongy. It must not be put into plastic bags or the crisper while wet. Under cool conditions celery will keep for several days at ordinary temperatures if the freshly cut ends of the stalks are placed in water, otherwise the bunch should be wrapped in plastic or waxed paper.

Root vegetables (carrots, parsnips, turnips and beetroot)

Bunched roots, because of the mass of leaves attached to them, have only a short life and if they are to be kept for more than a day or two the tops should be cut off. Root vegetables are not sensitive to chilling and topped roots will keep for several weeks in the refrigerator and for a few weeks in any cool place, but will need protection against drying out by keeping in vented plastic bags or well-lined boxes or other containers. At higher temperatures they will sprout fairly quickly.

Potatoes

New potatoes, that is potatoes that are not fully matured, have a thin skin, which is easily damaged, and a higher moisture content. Consequently, they do not keep well.

All potatoes must be kept in the dark. If exposed to light they gradually become green and develop an associated poisonous, bitter-tasting, alkaloid, solanin. When preparing potatoes for cooking, any tubers with pronounced greening should be discarded and any areas of greening on others should be completely removed.

Potatoes are sensitive to chilling — at temperatures below 10 °C the starch gradually turns into sugar so that they become undesirably sweet and if fried or baked go dark during the high temperature cooking. The lower the temperature the faster this sweetening occurs. They should therefore not be kept in the refrigerator. For ordinary domestic requirements, potatoes keep quite well in a cool, dark place.

If kept long enough, potatoes start to sprout. They have a natural dormant period after reaching maturity during which they will not sprout at any temperature. The length of this period of dormancy varies with the variety and may be as long as several weeks. At the end of this natural dormant period the rate of sprouting depends on the temperature. Sprouting may be prevented by treating the tubers with certain commercially available sprout-inhibiting chemicals, usually in the form of a dust.

Unwashed potatoes keep better than those that have been washed and, mainly because of damage to the skin, those that have been cleaned by heavy brushing do not keep well.

Sweet potatoes

Sweet potatoes are very sensitive to chilling and should not be stored at temperatures below 12 °C, except for very short periods. They should not be put in the refrigerator. Roots damaged by chilling develop sunken spots that turn into rots and the flesh discolours and breaks down. For safe long storage, sweet potatoes should first be cured by holding them under warm humid conditions for several days to allow any wounds to heal over. After that the best storage temperature is 15 °C at which later, better keeping varieties may be held for 3 months or more. At higher temperatures they will keep quite well but, of course, not for so long.

Onions

Onions are not sensitive to chilling and keep best at 0 °C but need dry air to avoid rooting and losses by rots. Bunched spring onions and shallots are quite perishable and, if to be kept for more than a few days, should be placed in the refrigerator, protected against wilting, where they should last for up to 3 weeks.

The life of onions depends very much on the variety, some early onions are poor keepers, while some late, brown varieties will keep for many weeks at ordinary temperatures if well matured, well cured, sound and clean. A well cured onion will have dry, firm outer scales and no noticeable neck. The main problems in the storage of onions are sprouting and rooting. Sprouting increases with temperature and rooting, as well as rotting, is encouraged by high humidities. Therefore in the home, onions should be stored in a cool, dry place.

Pumpkins, marrows and squashes

These are sensitive to chilling and liable to rotting if the humidity is high. They store best in dry air at 10–12 °C. Pumpkins should *not* be stored on a shed roof where they are exposed to sun, rain, cold night air and possible frosts. In the home, well-matured and carefully handled pumpkins will keep for a few months in any cool, dry and airy place. On the other hand, marrows and squashes keep only for a few weeks.

Immature pumpkins have a greenish, softer skin, pale flesh and a greenish stem. Both the eating quality and the keeping quality of immature pumpkins are poor.

Some marrows and squashes are eaten in the immature state and full maturity is a sign of poor quality. Because they are immature they will keep for only a short time.

As the growth of moulds is retarded by cold, cut pieces will often keep best in the refrigerator, where the cut surface should be allowed to dry out. However, if kept for more than about a week they become chilled, the tissues lose their resistance to attack by the ever present fungi, and rotting develops.

Tomatoes

Tomatoes are true fruits and will ripen to excellent quality after harvest if

- they are mature when picked, and
- the temperature is right.

Ripe, or even firm ripe tomatoes cannot be handled and marketed in the normal way. Therefore most tomatoes are picked in the 'mature green' or slightly coloured state and complete their ripening off the vine. 'Mature green' fruit will have lost the definite dull green colour of immaturity and the skin will be light to whitish green. The pulp will now be gelatinous with slight pink showing around the seeds. Fruit harvested at an earlier stage will ripen but slowly if at all and to inferior quality.

The ideal temperature for the ripening of tomatoes is 20 °C but ripening will be good within the range 18° to 25 °C, the ripe fruit being bright red and having firm flesh and good flavour. If the temperature during ripening is too low the ripe fruit will be pale and have a dry, granular texture and a poor, weak flavour. If the temperature is too high the fruit will ripen rapidly but will be yellowish, the flesh soft and the flavour poor. Thus, temperatures below 15 °C and above 30 °C are bad for the ripening of tomatoes.

The poor quality of tomatoes, so common in the shops, is due mostly to immaturity at harvest and/or to unsatisfactory ripening temperatures afterwards, often too hot in the summer and too cold in the winter.

Coloured tomatoes will keep for only about 7–10 days in the domestic refrigerator. The ideal temperature for the storage of mature green fruit is 10–12 °C, at which temperature they will ripen slowly and keep for 4 to 6 weeks. However, for satisfactory quality when fully ripe, once they have reached a light pink colour ripening must be completed at temperatures of 18° to 25 °C. At temperatures between 12° to 18 °C tomatoes will ripen to a more acceptable quality but their life will be shorter.

Chokos

Botanically, chokos are fruits and are sensitive to chilling. They keep best at 10–12 °C but will keep for a few days in the refrigerator before chilling becomes serious. At higher temperatures they ripen, toughen and soon start to sprout. In the home they are generally best kept not in the refrigerator but in the coolest alternative available.

Herbs

Parsley and other fresh herbs wilt and yellow rapidly at ordinary temperatures. They are best kept in the refrigerator in sealed plastic bags but must be cool and dry before bagging. They can also be put in the freezer in special freezer bags where they will keep for a few months without serious loss of flavour.

Fruit and vegetables — general

Increasingly, fresh fruit and the more perishable vegetables are being kept in a cold room attached to the retail store before being offered for sale. This cool storage is used to hold produce over the weekend or to hold lines bought in large quantity for longer periods. Although it may have warmed up appreciably, such produce will often be wet with condensed moisture when displayed for sale. Unfortunately, storage conditions in the coolrooms of the smaller shops are frequently inadequate and often the produce may, in any case, have been kept too long. As well as being wet it will often be limp, obviously not fresh and may also show signs of chilling injury. Such produce will not keep well and, if purchased, should be used as quickly as possible, bearing in mind the natural inherent keeping qualities outlined earlier.

More and more perishable produce is prepacked into plastic bags or plastic over-wrapped trays for self-service or other labour saving selling, especially in supermarkets. Potatoes should be removed from plastic bags and placed in a strong brown paper bag, box or tray in a dark place. If other lines are put into the refrigerator as purchased, and they are warm, the package will sweat and this free moisture inside will encourage rotting. Therefore for best storage the plastic should be torn or the produce removed before cooling and put back into a plastic bag or crisper after it has cooled down.

Waxing not only improves the keeping of citrus fruits but will also improve the keeping of certain other fruits for which definite ripening is required. These are cucumbers, passionfruit, capsicums and egg-plant. Root vegetables may also be waxed to reduce shrivelling. Commercially, specially formulated water-base wax emulsions are used. Some liquid floor polishes are water-base emulsions and can be used on perishable produce if diluted with one to two volumes of water. The produce is dipped in the diluted emulsion and dried on wire trays.

Dried fruit and nuts

Dried fruit

The main problems in keeping dried fruit in the house are insect infestation, development of mould in moist-pack fruit and, in dried tree fruits that are sulfured to maintain their colour, browning and the development of off-flavours due to loss of sulfur during storage. All three can be prevented by refrigeration, so that the best place to store dried fruit for long periods is in a sealed container in the coolest place available, ideally in the refrigerator.

To control insect infestation, dried fruit is either treated with a safe insecticide or sterilized by heat in the packing house.

Moist-packed ready-to-eat fruit is sterilized at the time of packaging and after opening should always be kept in the refrigerator to avoid development of mould.

The critical loss of sulfur (and subsequent rate of browning) from dried tree fruits is directly proportional to the initial sulfur content and the storage temperature. For best keeping and eating quality such fruit should be clean, with a bright clear natural colour and have a slight sulfurous smell (most of the sulfur is dissipated when the fruit is cooked).

Nuts

Nuts are also liable to insect attack and therefore should be kept in sealed containers. During storage the natural oils in the nuts gradually become rancid leading to the development of bitterness and off-flavours. The rate of the development of this rancidity is directly proportional to the temperature. Accordingly, nuts, too should be kept in a cool place. The development of rancidity is more rapid in shelled than in unshelled nuts, and is most rapid in nut pieces which should be used quickly unless kept in the refrigerator.

Points to remember

- Handle all perishable produce carefully — any breaks in the skin will allow deterioration and rotting
- Do not crowd stored produce, but ensure good air circulation
- Keep leafy vegetables in perforated plastic bags to slow down wilting and shrivelling, preferably in the refrigerator
- Keep potatoes in the dark to avoid 'greening', which may be poisonous
- Apples, pears, stone fruits and strawberries keep longest in perforated plastic bags in the refrigerator, but cool them first to avoid condensation
- Citrus fruits, cucumbers, passionfruit, capsicums and egg-plant will keep longer if waxed
- Dried fruits keep best in the refrigerator
- All fresh produce is temperature sensitive (see Appendix 1) and should be stored in the coolest part of the house (if not in the refrigerator)

Appendix

Storage life of fresh fruits and vegetables

	Best storage temperature (°C)	Approx. storage life (weeks)
A. Extremely perishable — very short life (0–4 weeks)		
Fruit		
Apricots	−0.5	2
Berry fruits	−0.5	1–2
Bananas (green)	12.5	2–3
Cherries	1	2–4
Custard apples	7	2–3
Figs	−1	2–3
Guavas	7–10	2–3
Loquats	1	1–2
Mangoes	10–12	2–3
Papaws	7	2–3
Vegetables		
Asparagus	0	2–4
Bunched roots	−0.5	1–2
Green beans	7	1–2
Broccoli	0	1–2
Brussels sprouts	0	2–4
Cauliflower	0	2–4
Green corn	−0.5	1–2
Chinese cabbage	0	1–2
Cucumbers	7–10	2–3
Lettuce	0	2–3
Green peas	−0.5	1–3
Melons (water, cantaloupe)	5–7	2–3
Melons (honey-dew, casaba)	7–10	4
Peppers (sweet), capsicums	7	2–3
Radish (without tops)	0	2–3
Rhubarb	0	2–3
Silver beet	0	1–2
Spinach	0	1–2
Tomatoes, coloured	7–10	1–2
Mushrooms	0	1–2
B. Perishable — short life (4–8 weeks)		
Fruit		
Avocados (Fuerte variety)	7	3–4
Avocados (other varieties)	5–12[A]	3–6[A]
Grapes (most varieties)	−0.5	4–6
Mandarins	5–7	3–6[A]
Nectarines[B]	−0.5	4–8[A]
Passionfruit	7	3–5
Peaches[B]	−0.5	2–6[A]
Pineapples	10	2–4
Plums[B]	−0.5	2–7[A]
Vegetables		
Cabbages (except large late)	0	4–6
Tomatoes (mature green)	12	3–6

	Best storage temperature (°C)	Approx. storage life (weeks)
C. Slightly perishable — medium life (6–12 weeks)		
Fruit		
Coconuts	0	8–12
Grapes (some late varieties)	−1	7–12
Limes	10	6–8
Oranges	5–7	6–12[A]
Persimmons (to ripen slowly)	10–12	6–8
Tomatoes (mature green)[C]	10–12	4–6
Vegetables		
Cabbage (late varieties)	0	6–12
Celery	0	6–10
Marrows	10–12	6–12
Some squash	10–12	6–12
Early onions[D]	0	6–12
D. Non-perishable — long life (more than 12 weeks)		
Fruit		
Apples	−1–3[E]	8–28[E]
Grapefruit	10–12	10–16
Lemons	12	12–20
Nuts	−1	Up to 50
Pears[F]	−1	8–28[A]
Quinces	0	8–16[A]
Vegetables		
Beetroot (topped)	0	12–20
Carrots (topped)	0	12–20
Onions (later varieties)[D]	0	12–28
Parsnips (topped)	0	12–20
Pumpkins[D]	10–12	12–24
Potatoes	7	16–24
Sweet potatoes	12	16–24
Swede turnips	0	16–24

[A] According to variety.
[B] Very perishable at higher temperatures.
[C] Will ripen slowly but when light pink ripening must be completed at 18–25°C for satisfactory quality.
[D] Dry air, relative humidity 70–75%.
[E] Depending on variety and climate.
[F] Very perishable at temperatures above 10°C.

The longer keeping kinds of produce can be stored safely for correspondingly shorter periods at temperatures higher than the optimum temperatures for best keeping listed above.

Fuel from fruit and vegetable wastes

Australian fruit and vegetable processing factories produce about 750000 t (wet weight) of waste solids per year, with annual quantities from individual producers ranging up to 35000 t.

Disposal of such quantities of wet, putrescible, organic refuse creates major environmental and economic problems for which no satisfactory solutions have yet been found. At present, fruit and vegetable solid wastes are usually disposed of by dumping, spreading and burning as well as by feeding to animals. The wastes have a crude protein content of only 3.5–4.5%, so have little value as feed for beef or dairy cattle. As a result, the wastes have virtually no market value and are usually offered to local farmers free of charge at their own cartage. Even on these terms, carting the materials more than a few miles is uneconomic. High transport costs also make disposal by dumping, spreading and burning expensive; for example, removal of citrus wastes from one juicing plant costs about $75000 per year.

At the CSIRO Food Research Laboratory, North Ryde, anaerobic digestion ('biogas process') is being investigated by a team led by Dr A. G. Lane as a means of converting fruit and vegetable waste solids into methane (CH_4) fuel.

Results from laboratory-scale digesters and a 3700-litre pilot unit showed that waste solids from a number of fruit and vegetable processing operations could be virtually completely converted to gas, leaving almost no residue. Pelletized orange peel used as feedstock in extensive trials yielded 450 litres of gas per kg (dry weight) at loadings up to 4 kg m^{-3} of digester capacity per day.

The composition of the gas produced from fruit and vegetable waste solids was 50–55% CH_4 and 45–50% CO_2 by volume, consistent with that expected from carbohydrate feed stocks. The calorific value of the gas was 18.3–19.8 MJ m^{-3} which is lower than that for gas produced from sewage sludge or livestock wastes, and the flame velocity was also lower because the CO_2 content was higher. Nevertheless, the gas was found to burn well when mixed before ignition with the correct proportion of air in a turbulent premixing chamber.

The economics of the process could not be fully assessed from results obtained in these trials but calculations based on these data showed that a hypothetical processing plant with an annual output of 30000 t (wet weight) of solid waste at 80% moisture content could generate 2.7 x 10^6 m^3 of gas per year.

If low grade waste heat were used to maintain the temperature of the digester, the power needed for other digester operations would probably consume only 20% of the gas produced. Thus the volume of surplus gas would be 2.2 x 10^6 m^3, equivalent in calorific value to 1.5 x 10^6 litres of petrol. To the value of the gas as fuel should be added the savings by avoiding charges for transporting and dumping the waste, amounting at \$4 t^{-1}, to $120000. The savings would of course be reduced by capital charges, staffing and cost of supplementation.

These rough calculations indicated that, besides providing an environmentally acceptable means of disposing of fruit and vegetable processing solid wastes, anaerobic digestion would produce enough methane to supply an important part of the fuel needed in the processing operation.

A pilot scale digester of 25 m^3 capacity has now been constructed at the Letona Co-operative Cannery Ltd, Leeton, N.S.W. to extend trials with the anaerobic digestion process to an industrial situation. The plant was constructed jointly by the CSIRO Divisions of Food Research and Irrigation Research and the Letona Co-op. Cannery and is operated on a day-to-day basis by the staff of the cannery. The digester has a design loading of 100 kg (dry weight) per day, supplied as 0.5–1 t wet waste, and was designed as a 1 : 20 scale version of the digester required to treat all of the waste generated by the factory.

The plant was officially commissioned at a ceremony at the Letona Co-op. Cannery on Friday 27 April 1979. The ceremony was attended by Dr P. Kriedemann (Chief, Irrigation Research), Dr J. H. B. Christian

Visitors inspecting anaerobic digestion plant for fruit and vegetable wastes, Letona Co-op. Cannery, Leeton, N.S.W., 27 April 1979.

(Chief, Food Research) and other members of CSIRO, together with representatives from the food-processing industry and the Wade and Leeton Shire Councils. A highlight of the processing came when Dr Kriedemann lit a barbecue and the gas from the digester was used to cook lunch for the assembled guests.

At this time the digester was operating at 36 °C and was being fed peach waste at the rate of 0.72 m^3 of waste per day at 9% solids, which represented 2.8 kg dry weight m^{-3} per day, and yielded 0.33 m^3 of gas (55% methane) per kg dry matter. After a conditioning period, the loading rate will be gradually increased to the anticipated maximum of 4–4.5 kg m^{-3} per day. Wastes from processing of apricots, peaches, pears and apples are being fed to the digester as each crop comes into season. Data obtained during these trials will allow the economics of the process to be evaluated and its industrial potential to be assessed. An appraisal of the process will be published when trials are completed.

How much collagen in Australian canned meats?

By P. W. Board, W. A. Montgomery and P. J. Rutledge
CSIRO Division of Food Research, North Ryde, N.S.W.

Regulations in some countries include controls on the proportion of connective tissue in meat products. These are expressed in terms of maximum limits for collagen and elastin, the principal proteins in connective tissue.

As there was no published information on the collagen content of Australian canned meats, an investigation was undertaken of representative products in current production. The results of this investigation were reported in full by Board *et al.* (1978).

Products examined

Samples of the following canned meats, namely corned beef, corned beef with cereal, ham, cured pork shoulder, and comminuted ham products, were taken at random from canning lines in 11 meat canneries in several States. Altogether, 146 cans of product were examined individually for collagen content by means of the ISO (1972) method which is based upon the determination of hydroxyproline, an amino acid that in muscle proteins occurs only in the collagen. In addition, moisture, salt, fat and protein contents were estimated by the methods of the AOAC (1970).

Results of analyses

The analytical results for the canned meats examined are presented in the table.

In Australian corned beef the mean percentage of collagen in total protein was 14.0% which was less than Hauser (1975) found in South American (17.5%) and European-style (26.7%) canned corned beef. The variation from about 12 to 18% in the means for the six lots examined arises from variation in the quality of the animals processed and in the type and proportions of different cuts used. Similar considerations influenced the composition of the corned beef with cereal packs.

In canned hams and pork shoulders the average amount of collagen in total protein was less than 10%. These products are produced from animals that are likely to be more uniform in quality than the cattle used for corned beef and, moreover, they are prepared from defined cuts, the leg and shoulder. Comminuted ham products, however, are prepared from mixed cuts, including trimmings from the major cuts, and the collagen content tends to be higher.

Discussion

The motivation for regulatory authorities to set minimum limits for collagen-free meat protein appears to arise from the observations that cuts with low levels of collagen tend to have higher biological values and to be more tender than cuts with high levels of collagen. Thus Bender and Zia (1976) reported that shin beef containing 23.6% collagen in the protein and fillet with 2.5% collagen had net protein utilization values of 69 and 82 respectively. However, these authors concluded that this difference in nutritive value was unlikely to be of practical importance in the diet as a whole, and that the difference in price between the two grades of meat was much greater than was justified by the difference in nutritive value.

The effect of connective tissue on tenderness is chiefly significant in the consumption of fresh meat. Indeed it may be argued that canning is a process whereby tough cuts of meat may be made tender and palatable. Moreover, in many canned meats 'sliceability' becomes a dominant quality attribute and Australian canneries often select cuts for canned corned beef for its high content of connective tissue in order to achieve good sliceability.

If limits are to be set for protein quality in canned meats they should be sufficiently

Composition of Australian canned meats[A]

Lot No.	No. of cans	Salt %	Moisture %	Fat %	Protein %	Collagen %	SD of % collagen	Collagen as % of total protein
Corned beef								
1	18	2.52	56.6	14.9	25.9	3.46	0.54	13.3
2	6	3.19	64.5	15.5	15.3	1.88	0.34	12.3
3	8	2.26	59.0	15.5	22.2	4.08	1.28	18.4
4	12	2.15	56.1	17.6	25.1	3.21	0.44	12.8
5	3	2.03	57.2	15.6	26.0	3.17	0.33	12.2
6	5	1.48	56.0	22.9	19.9	3.06	0.67	15.4
Mean		2.34	57.8	16.5	23.3	3.26		14.0
SD		0.50	3.1	3.2	3.8	0.87		
Corned beef with cereal								
7	6	2.17	55.0	17.5	20.3	2.80	0.36	13.8
8	12	2.51	62.0	14.7	18.0	1.95	0.20	10.8
9	12	2.22	62.1	13.7	16.0	2.23	0.52	13.9
10	3	2.78	61.2	14.7	15.0	2.01	0.53	13.4
11	3	2.16	64.9	10.8	16.3	1.54	0.32	9.5
Mean		2.35	61.0	14.5	17.3	2.16		12.5
SD		0.35	3.8	2.9	2.0	0.15		
Ham								
12	6	4.01	74.4	3.5	17.3	0.99	0.29	5.7
13	6	2.67	73.0	6.0	16.2	1.69	0.78	10.4
14	3	3.67	75.8	3.4	15.6	1.43	0.48	9.2
15	4	3.54	70.4	9.4	15.3	1.27	0.51	8.3
16	6	2.82	74.0	4.9	17.0	1.87	0.38	11.0
Mean		3.28	73.5	5.4	16.5	1.46		8.9
SD		0.69	2.1	2.6	1.4	0.59		
Cured pork shoulder								
17	6	2.93	73.0	7.4	15.7	1.75	0.19	11.1
18	6	2.66	72.9	7.8	15.5	1.09	0.24	7.0
19	2	2.80	60.8	19.4	16.8	1.64	0.53	9.8
20	6	3.17	68.9	8.6	16.5	1.31	0.10	7.9
21	1	3.48	72.2	7.9	15.8	1.63	—	10.3
22	1	3.15	73.1	7.9	12.9	2.16	—	16.7
Mean		2.94	70.7	9.0	15.9	1.45		9.1
SD		0.35	4.0	3.9	1.1	0.37		
Comminuted ham products								
23	6	3.07	57.9	24.0	12.9	1.76	0.36	13.6
24	5	3.32	52.3	28.8	13.1	1.69	0.46	12.9
Mean		3.18	55.4	26.2	13.0	1.73		13.3
SD		0.43	3.6	3.7	0.4	0.39		

[A]From Board *et al.* (1978).

flexible to allow canners to produce for markets that differ in their capacity to buy canned meats. In addition, it is important to make optimum use of the meat on a carcass, and canning is one way of making acceptable products from less tender cuts.

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Research at FRL supported jointly by industry and government

While the Division of Food Research is funded mainly by the Department of Finance, it has for many years received highly encouraging supplementary support from other sources, notably in support of the work of MRL and DRL. Because of recent constraints in Commonwealth spending, contributed funds from industry have now become essential for the maintenance of research output. A number of segments of the food industry have taken advantage of the arrangements that are available for sharing in the support of research. It is of interest to describe the projects at FRL that are funded in this way.

Commodity research trusts

Commonwealth legislation has set up a number of commodity research trusts that are financed by levies on the respective industries together with matching Commonwealth grants. In some instances the levies support education and market promotion as well as research. Research grants are made on the recommendation of committees made up generally of representatives of the industry, the Australian Agricultural Council, the Commonwealth Department of Primary Industry, the universities and CSIRO. It is from the Australian Meat Research Committee and Dairying Research Committee that MRL and DRL respectively receive major funding.

Taint in prawns

The Fishing Industry Research Committee has for some years supported fish products research at the Division's Tasmanian Food Research Unit. Currently it is supporting a project at FRL, conducted by Mr J. H. Last under the supervision of Dr F. B. Whitfield, on the identification of compounds responsible for 'iodoform-like' off-flavours in prawns and edible crustaceans.

Some edible crustaceans including prawns, bay lobsters and crabs are sometimes found to have off-flavours that are commonly described as 'like iodoform'. The off-flavour may be so intense that the seafood is unacceptable, and certain species may be discarded after costly harvesting. The aim of this project is to establish whether the off-flavours are caused by natural components of the diet of the sea creatures or by metabolites produced by bacterial action in the gut. It is hoped that it will then be possible to develop handling procedures that will minimize the incidence of off-flavours in susceptible species.

Dried vine fruits

A project under the supervision of Mr D. McG. McBean on the development of new products from dried vine fruits is being supported by the Dried Fruits Research Committee.

The Australian dried vine fruit industry is profitable at present mainly owing to a shortage on the world market caused by abnormal weather in the northern hemisphere. It is unlikely that similar circumstances will occur again and under normal conditions Australian dried fruits will face severe competition. The project aims to find additional outlets for Australian dried vine fruits by developing new products in which they would be included. Some of the proposed new products are: fruit bars, spreads, canned desserts, drum-dried products, and products of reduced sugar content. The Division is also about to start a program to collect definitive information about the shelf life of a range of important Australian foods and it is appropriate to include sultanas, currants and raisins in such a study. Products such as fruit cake and canned pie fillings, which contain large amounts of dried vine fruits, as well as any promising new products from the project will also be included.

Broiler chickens

In the broiler industry, birds with a high growth rate are typically fed high energy grain diets. This practice may result in carcasses with excessive quantities of fat, particularly in the abdominal, gizzard and visceral regions. To comply with consumer demands, much of this fat must be removed and used as a by-product at greatly reduced value when compared to the lean tissue. Only through a greater understanding of fat metabolism in the chicken can we expect to reduce the deposition of excess fat and thus increase retail yield, profitability to the producer, and acceptability to the consumer.

These are the commendable aims of a project conducted by Dr Ross Hood and supported by the Chicken Meat Research Committee.

Commonwealth special research grants

The Commonwealth Government, through the Department of Primary Industry, also offers special grants for research on the more efficient production, handling, storage, transport and utilization (including processing and marketing) of primary commodities, *excluding* those for which specific research schemes already exist. Industries benefiting from Commonwealth Special Research Grants are required to provide dollar for dollar matching funds.

In co-operation with the respective industries, the Food Research Laboratory is receiving Commonwealth Special Research Grants in support of two projects.

Grapefruit juice

A project on procedures to improve the quality of processed grapefruit juice is being supported by the Australian Citrus Growers Federation and will be carried out under the supervision of Dr B. V. Chandler.

Australian processed grapefruit juice is generally not well accepted by consumers because it tends to be too sour and too bitter. It is difficult to market the Australian grapefruit crop of 20 000 t at prices that give reasonable returns to growers. The project aims to attack the problem of improving the quality of grapefruit juice from two directions — by optimization of fruit quality and by debittering the processed juice.

Previous work by Dr Chandler's group indicated that it may be possible to predict when to harvest an orange crop to obtain fruit of specified quality from analyses of sample picks of the crop taken several months before commercial maturity. Grapefruit crops will now be examined for physical and chemical characteristics at regular intervals during development and maturation to determine whether the method proposed for predicting the quality of oranges is applicable to grapefruit.

Dr Chandler's group has also developed procedures for debittering navel orange juice by contact with cellulose acetate gel beads which adsorb the bitter principle, limonin. The bitterness in grapefruit juice is due to both limonin and naringin. Cellulose acetate beads will not remove naringin but preliminary trials indicate that polyamide is an effective adsorbent. Further work is necessary to prepare polyamide in a form suitable for a viable commercial de-bittering process.

Peanuts

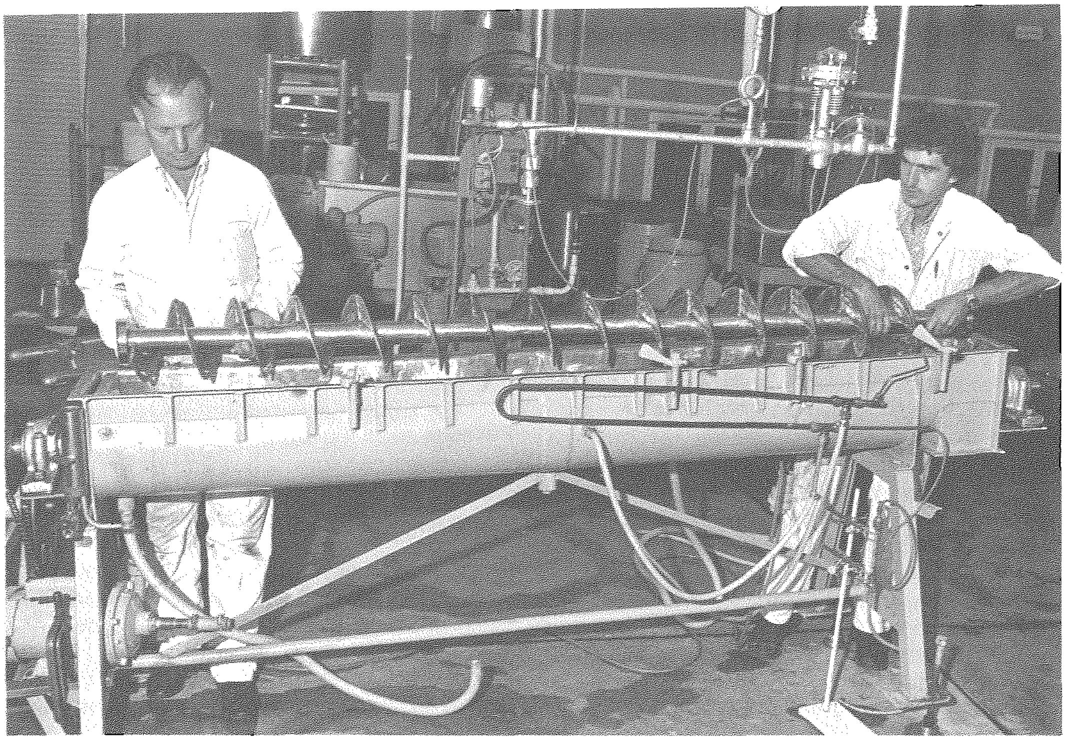
To assist the Australian peanut industry with measures for the effective processing and storage of peanuts in order to prevent mycotoxin production or other deleterious changes after harvest, a project has been undertaken by Dr J. I. Pitt with support from the Queensland Peanut Marketing Board. Aflatoxin has become of critical importance to the peanut industry and there is need for a detailed field and laboratory examination of harvesting, shelling, storing and processing, with the aim of eliminating possible points where mould growth and mycotoxin production might occur. In addition, knowledge is lacking on the effects of humidity and temperature on growth and mycotoxin production by Australian strains of *Aspergillus flavus* and other toxigenic moulds.

The Reserve Bank

The Rural Credits Development Fund of the Reserve Bank of Australia makes grants for research, development or extension projects which are seen to provide potential benefits to primary industry.

From this Fund support has been received for projects aimed at developing a screening test for resistance to chilling injury in fruits and vegetables; extraction of juice from grapes by means of a counter-current extraction procedure; tomato quality and vine-holding capacity.

Countercurrent or diffusion extraction, first applied to extraction of sugar from sugar beet and more recently to extraction of apple juice, has not previously been applied to grapes. It will be investigated by Dr D. J. Casimir as a means for producing grape juice and grape juice drinks, particularly from red



Positioning the screw in the pilot scale countercurrent extractor.

grape varieties that are now in oversupply in Australia. The process could also be of interest for the extraction of juice for wine making because excellent extraction of red anthocyanin pigments is achieved.

A project aimed at improving the quality of fresh table tomatoes and the vine-holding characteristics of processing tomatoes is being undertaken in collaboration with Dr E. C. Tigchelaar, Purdue University, U.S.A. and the N.S.W. Department of Agriculture.

Generally, consumers equate quality in table tomatoes with those picked when fully coloured. This ideal is difficult to achieve in practice. Ripe fruits of F1 hybrids incorporating the *nor* mutant gene deteriorate much more slowly than fruits of normal strains and field trials are being carried out to test the utility of *nor* hybrids for the fresh table market.

Parallel work is also being undertaken with advanced lines of processing tomatoes for machine harvesting by the incorporation of the *nor* gene F1 hybrids as this is expected to improve their vine-storing properties very considerably.

Also working in FRL under a Reserve Bank Research Fellowship (Agriculture) is Dr A. J. G. Pirie of the Riverina College of Advanced Education. His project is concerned with high pH in Australian red wines and its relation to potassium uptake by grapevines.

Apple and Pear Corporation

For several years the Australian Apple and Pear Corporation has supported a project on apple processing conducted by Miss Helen Woods. In addition to investigations mainly on apple juice products, the project has involved widespread extension work requiring visits to apple processors throughout Australia. Future work is planned on cloudy apple juice concentrates and on the stability of vitamin C in apple juice.

Rotary drum freezer suitable for laboratory use

By B. Cain

CSIRO Division of Food Research, Cannon Hill, Queensland.

This small surface-freezer, which was designed for research and development work, has proved a very useful and flexible piece of equipment, and has been used to flake-freeze milk and various protein solutions (Hamilton 1978*a*, *b*), and also to produce gelatin film.

The unit is based on the design concept used in large drum freezers but is suitable for laboratory use because it is quite small and mobile.

The refrigeration equipment (a low-temperature, glycol-circulation system) can be utilized separately to the freezing drum, thus providing a source of refrigeration for other purposes.

The whole assembly is simple and easily fabricated in a laboratory workshop. The total cost of manufacture was *c.* $2500. Because the refrigeration system is a sealed unit and the drum operates at a low speed in a 'ralloy' bearing, the equipment is virtually maintenance free.

Dimensions of the unit may be changed to adapt it for various purposes but the basic design would remain the same.

Description

The unit can be divided into two sections – the refrigeration equipment and the freezing drum.

The refrigeration equipment

A sealed refrigeration unit of 0.4 kW capacity operating on R12 refrigerant on capillary tube expansion is mounted in a ventilated compartment below a copper tank to hold the glycol solution.

This copper tank is surrounded by 50 mm of polystyrene insulation and is fitted with a copper refrigeration coil with ample surface area to load the refrigeration unit to capacity.

The temperature of the glycol can be controlled by the thermostat to any level within the selected range, with a differential of ±0.5 °C. Temperatures to below −20 °C can be maintained. The tank has a lockable, hinged lid for access.

A self priming, centrifugal pump, directly driven by a 240-V motor is mounted in the base section and used to circulate the glycol. The pump has its own on/off switch. The pump draws glycol from the bottom of the tank and discharges it to an outlet mounted at one end of the cabinet. A return pipe is mounted adjacent to the discharge outlet. Both discharge and return lines project 100 mm from the unit. This allows suitable hoses to be connected.

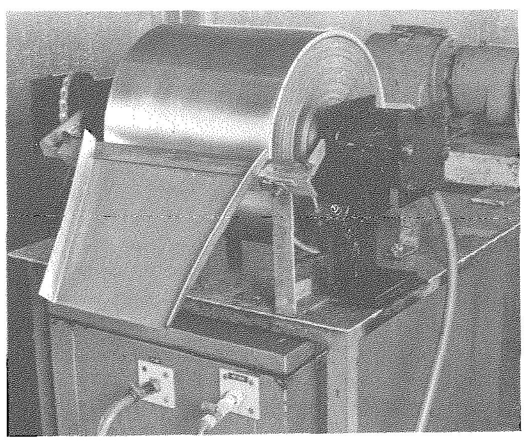
The whole cabinet is finished in enamelled, zinc annealed sheet and mounted on castors for mobility. The ventilation of the base section gives a positive air flow over the condensing unit.

The system runs on single phase power with on/off switch, pump on/off switch and temperature controls mounted on one end of the unit.

The unit has the capacity to make about 100 kg of ice per day.

The rotary drum

The drum is a length of 300 mm nominal bore mild steel pipe. The shaft was machined



Rotary drum freezer.

and the sheet metal infill spacer fixed to it. The drum ends were welded to the shaft and the drum. The whole unit was then turned between the bearing surfaces and machined to true round. It was then surface ground and hard chrome finished. All stainless steel could be used, except that the cost would be greatly increased.

The drum is mounted above a flat table top so that it can rotate freely over a tray of feed material positioned beneath it. The drum is driven by either a variable speed motor or, if the speed requirement is known, a gear motor. A speed of about 3–4 rpm (surface speed of 60 mm s^{-1}) works well for the freezing of meat protein solution.

The drum as a freezer

The discharge and return lines from the recirculation pump of the refrigerating system are connected by flexible hoses to the ends of the drum shaft. The refrigeration unit is left running until the temperature of the glycol falls to that selected. The drum drive and the pump motor are then switched on and the solution to be frozen is fed to the tray.

The feed solution in the tray should not be allowed to freeze. This can be prevented by the use of a small pump to recirculate continuously the solution between the tray and a bulk supply of the solution.

A scraper blade is mounted on the table top and adjusted to *c.* 0.5 mm from the drum surface. The blade is of stainless steel angle with one edge sharpened for scraping. The angle gives the blade increased rigidity. The ice is scraped off the drum and slides down a chute to a collection vessel.

The whole system occupies a space of 650 × 950 × 1300 mm. The refrigeration system is located under the table top on which the drum is mounted.

Where a refrigeration capacity in excess of 0.4 kW is required a larger sealed compressor unit may be used.

Drawings and further details of the unit may be obtained from the Meat Research Laboratory.

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Guide to CSIRO's research

A comprehensive directory of CSIRO's research activities is now available. Titled *CSIRO Research Programs 1979–80*, it costs $10 and can be ordered from the Editorial and Publications Service, CSIRO, P.O. Box 89, East Melbourne, Vic. 3002.

The directory contains descriptions of all current research programs and subprograms — there are more than 700 of them — and provides details of locations, staff numbers and expenditure. The problems being tackled and possible implications of research findings are described, as well as the research.

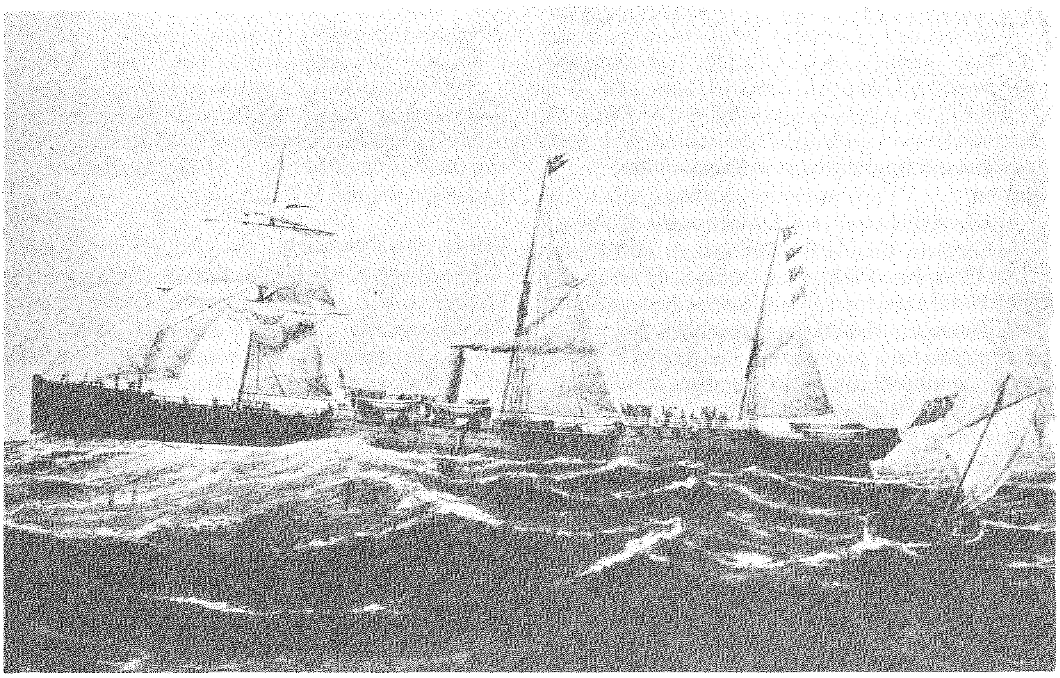
The directory has over 500 pages, and it is seen primarily as an information source for people in industry, government, and research and educational institutions who have an interest in CSIRO's work. It has been written in non-technical language and a comprehensive index is included. The directory has been placed in public libraries around Australia.

Nutrient content of processed foods

The Division has recently released a pamphlet discussing the need for processed foods and the loss of nutrients that may occur during harvesting, handling, transport, preparation, processing, storage and distribution, as well as during the handling and preparation of food in the home, restaurant or institution.

It lists the steps that should be followed in order to retain the maximum amounts of nutrients during the preparation and cooking of food, and summarizes the effect of processing on the nutrient content of foods.

Copies of the pamphlet 'The nutritional value of processed foods' may be obtained by sending a stamped, addressed, 230 × 100 mm envelope to Mr. G. Fisher, Liaison Section, CSIRO Division of Food Research, P.O. Box 52, North Ryde, N.S.W. 2113. Telephone (02) 887 8333.



s.s. Strathleven, which in 1879 carried the first successful shipment of frozen meat and butter from Australia to England.

Strathleven Centenary Symposium: Preliminary announcement

In November 1879 s.s. Strathleven left Sydney with a cargo of frozen meat and butter which was discharged in good condition in London in February 1880 — the first successful overseas shipment of frozen food.

In view of the importance of this shipment as a technological innovation that had immediate effects on world trade in foodstuffs, the CSIRO Division of Food Research will hold a *Strathleven Centenary Symposium on Food Refrigeration* at the Food Research Laboratory, North Ryde, on Tuesday and Wednesday, 26 and 27 February 1980.

The Symposium will attempt to define the limits of knowledge on refrigeration of foods and areas where research is needed and likely to be profitable. Four half-day segments are planned on *Refrigeration of meats and meat products*, *Transport and storage of refrigerated foods*, *Refrigeration of fruits and vegetables*, and *Refrigerated foods in the supermarket.*

The registration fee is $35. This covers costs of printing and catering, and provides some support for visiting speakers.

Programs and registration forms are available from Mr G. Fisher, Technical Secretary, CSIRO Food Research Laboratory, P.O. Box 52, North Ryde, N.S.W., 2113; telephone (02) 887 8333; Telex AA 23407.

The closing date for registration is 31 January 1980.

Anti-scald agent

Further to the note in *CSIRO Food Research Quarterly* 39 (1), (16 March, 1979), West Germany now accepts apples and pears treated with diphenylamine with a maximum residue level of 3 mg kg^{-1}, under an ordinance which came into effect on 1 August 1978.

News from the Division

Postharvest horticulture in Papua New Guinea

At the request of the Government of Papua New Guinea, Dr W. B. McGlasson and Mr G. R. Chaplin, FRL, and Dr B. S. Harrap, CSIRO Centre for International Research Co-operation, visited the principal production and population centres of PNG to advise on problems in production, handling, storage and transport of fresh fruit and vegetables. The Government of PNG aims to make the nation largely self-sufficient in food, and actively encourages production of a wide range of foodstuffs including fresh fruit and vegetables. As far as possible, food production is to be expanded near population centres to minimize transport costs. However, the population is expanding faster in urban communities than in rural areas and produce will have to be grown on a larger scale to meet the needs of the urban communities. This will necessitate the application of postharvest methods that are economical and yet minimize wastage and maintain quality.

Papua New Guinea is critically short of people trained for development and extension in postharvest handling. In their report, Dr McGlasson, Mr Chaplin and Dr Harrap emphasize the need to establish a firm base for training, research, and development in this field. They propose that CSIRO advise on the design of research facilities and the conduct of postharvest investigations, as well as provide opportunities for PNG graduates to gain experience by working in CSIRO laboratories.

Overseas visitors

On 18 May 1979 FRL was visited by two senior government officials from Bahrein — Mr Ahmed Hubail, Director of Company Affairs, and Mr Sidiq Al-Alawi, Chief Agricultural Engineer.

Dr Lien Wen Sye from the Singapore Institute of Standards and Industrial Research spent a week at FRL, 13–17 August 1979, gaining knowledge and experience on food packaging in flexible plastic films. The following week she spent in Melbourne under the guidance of Mr S. J. Muir, Kraft Foods Ltd, and visited DRL.

Study visit overseas

Mr Peter J. Rutledge, Senior Technical Officer in the Applied Food Science Group, FRL, has been granted a CSIRO Study Award for training and experience overseas. He will work for six months from April 1980 at the Campden Food Preservation Research Association, Chipping Campden, Gloucestershire, England, where he wishes to study recent technological advances in food processing and procedures for the dissemination of technical information to industry.

Specialist course

Specialist Course for the Food Industry No. 6 on Food-borne Microorganisms of Public Health Significance was conducted for the third time at the University of New South Wales 8–13 July 1979. This Course is organized by FRL in collaboration with the University's Department of Food Technology and the Food Microbiology Group of the Australian Institute of Food Science and Technology, and is accompanied by a comprehensive manual of lectures and laboratory procedures. The manual is available for sale at $A27 post free within Australia and $A32 post free overseas, from the Technical Secretary, CSIRO Food Research Laboratory, PO Box 52, North Ryde, N.S.W., 2113.

Meat schools

Officers of the Division in co-operation with Hawkesbury Agricultural College and the Australian Meat and Livestock Corporation were involved in a Meat Canning Technology School, 9–13 July, and a Meat Quality Control School, 22–29 July, both held at the College in the School of Food Sciences.

Fish handling and quality control

Allan Bremner, Stephen Thrower, and Alex Vail of the Tasmanian Food Research Unit contributed talks and demonstrations to a Fish Handling and Quality Control

Workshop, 29–31 May, and a National Fisheries Officers Course, 24 September–5 October, both held in Port Lincoln, S.A., under the auspices of the Commonwealth Department of Primary Industry and the South Australian Department of Agriculture and Fisheries.

General

Dr J. H. B. Christian, Acting Chief, has been appointed to the Council of the Bread Research Institute of Australia.

Dr A. R. Johnson, Officer-in-Charge of FRL, is CSIRO representative on the Australian Poultry Research Advisory Committee.

Dr N. S. Parker has been named Leader of FRL's Electronics Section.

Work overseas

The U.S.–Australia Science Agreement sponsored a 10-day visit to the University of Hawaii of Drs Graham, Smillie, Raison, Patterson, Bishop and McMurchie, late in March, to discuss the role of membranes in low temperature stress in crop plants.

The Acting Chief of the Division, Dr J. H. B. Christian, was Australian Delegate at the Codex Food Hygiene Committee Working Party in Geneva and acted as a Consultant to W.H.O., at the end of February. He then attended a combined meeting of Microbiology Groups of the International Dairy Federation in Brussels.

Messrs L. L. Muller, J. G. Zadow, and S. C. Marshall of DRL attended a New Zealand Whey Workshop at the N.Z. Dairy Research Institute, Palmerston North in early April, under the auspices of the U.S.–Australia Science Agreement.

Dr D. G. Oakenfull, FRL, commenced a year's visit to the Chemical Laboratory, University of Kent at Canterbury, England, in mid-February. He will continue his studies on the importance of fibre in the human diet, begun at FRL.

Dr A. G. Lane visited Bali, Indonesia, to attend the 9th meeting of the ASEAN Subcommittee on Proteins. He represented the Australian Department of Foreign Affairs (ADAB) as an invited expert on food waste programs.

Dr D. J. Walker, Officer-in-Charge of MRL, presented two invited papers to the 6th International Congress on Veterinary Science at La Plata University, Argentina. He also visited meat research and meat processing centres in Argentina and Brazil.

Dr W. B. McGlasson and Mr G. B. Morgan of FRL assessed the need for overseas aid in connection with the ADAB-Australian aid to Bhutan Horticulture Industry Project, when they travelled to India and Bhutan in April and May.

Selected publications of the Division

Copies of most of the publications listed below are available from the Librarian of the laboratory indicated.

From the Dairy Research Laboratory

Hill, R. D., Van Leeuwen, Veronica, and Wilkinson, R. A. (1977). Some factors influencing the autoxidation of milks rich in linoleic acid. *N.Z. J. Dairy Sci. Technol.* 12, 69–77.

Hill, R. D., and Zadow, J. G. (1978). The precipitation of whey proteins with water soluble polymers. *N.Z. J. Dairy Sci. Technol.* 13, 61–4.

Keogh, Barbara P. (1978). Microorganisms in dairy products — friends and foes. *Aust. J. Dairy Technol.* 33, 41–5.

Keogh, Barbara P., and Dick, M. I. B.* (1978). The microbial spoilage of dairy foods — the Australian scene. *Food Technol. Aust.* **30**, 377–80.

Rogers, W. P. (1978). The determination of moisture in butter using an oscillating hot plate. *Aust. J. Dairy Technol.* 33, 26–30.

Timms, R. E. (1978). Automatic determination of the softening point of milk fat, milk fat fractions and butter. *Aust. J. Dairy Technol.* 33, 143–7.

Zadow, J. G., and Hardham, J. F. (1978). The influence of milk powder, pH and heat treatment on the reflectance and stability of recombined milk sterilized by the ultra high temperature process. *Aust. J. Dairy Technol.* **33**, 6–10.

*Not a member of the Division

Zadow, J. G., and Hill, R. D. (1978). The formation of complexes between whey proteins and carboxymethyl cellulose modified with substituents of increased hydrophobicity. *J. Dairy Res.* 45, 85–92.

From the Food Research Laboratory

Banks, H. J.,* and Sharp, A. K. (1979). Insect control with CO_2 in a small stack of bagged grain in a plastic film enclosure. *Aust. J. Exp. Agric. Anim. Husb.* **19**, 102–7.

Barnett, D. (1978). Determination of lipid residues resulting from treatments used in the processing of raisins and sultanas. *Food Technol. Aust.* **30**, 498–502.

Board, P. W., and Steele, R. J. (1978). Calculating heat sterilisation processes for canned foods. *Food Technol. Aust.* **30**, 169–73.

Chandler, B. V., and Johnson, R. L. (1977). Cellulose acetate as a selective sorbent for limonin in orange juice. *J. Sci. Food Agric.* **28**, 875–84.

Davis, E. G. (1978). The performance of liners for retail wine casks. *J. Food Technol.* **13**, 235–41.

Lane, A. G. (1979). Methane from anaerobic digestion of fruit and vegetable processing wastes. *Food Technol. Aust.* **31**, 201–7.

Murrell, W. G. (1978). The spoilage of canned foods. *Food Technol. Aust.* **30**, 381–4.

Rigney, C. J.,* Graham, D., and Lee, T. H.* (1978). Changes in tomato fruit ripening caused by ethylene dibromide fumigation. *J. Am. Soc. Hortic. Sci.* **103**, 420–3.

Scott, K. J., and Chaplin, G. R. (1978). Reduction of chilling injury in avocados stored in sealed polyethylene bags. *Trop. Agric. (Trinidad)* **55**, 87–90.

Steele, R. J., and Board, P. W. (1979). Amendments to Ball's Formula Method for calculating the lethal value of thermal processes. *J. Food Sci.* **44**, 292–3.

Wild, B. L.,* McGlasson, W. B., and Lee, T. H.* (1977). Ethylene in CA long term lemon storage. *Proc. Int. Soc. Citriculture* **1**, 259–63.

From the Food Research Unit, Hobart

Olley, June. (1978). Current status of the theory of the application of temperature indicators, temperature integrators, and temperature function integrators to the food spoilage chain. *Int. J. Refrig.* **1**, 81–6.

Olley, June, and Thrower, S. J. (1977). Abalone — an esoteric food. *Adv. Food Res.* **23**, 143–86.

Thrower, S. J. (1977). Blue spot in abalone — possible causes and solutions. *Aust. Fish.* **36**, 6–7, 13, 30.

From the Meat Research Laboratory

Bouton, P. E., Harris, P. V., Macfarlane, J. J., O'Shea, J. M.,* and Smith, M. B. (1978). Pressure-heat treatment of meat: effect on connective tissue. *J. Food Sci.* **43**, 301–3, 326.

Ford, A. L., Jones, P. N.,* Macfarlane, J. J., Schmidt, G. R.,* and Turner, R. H. (1978). Binding of meat pieces: objective and subjective assessment of restructured steakettes containing added myosin and/or sarcoplasmic protein. *J. Food Sci.* **43**, 815–8.

Graham, A. (1978). Energy use in abattoirs and the potential for energy conservation by waste heat recovery from pollution control devices. *Food Technol. Aust.* **30**, 105–8.

Grau, F. H. (1978). The spoilage of meat and meat products. *Food Technol. Aust.* **30**, 385–8.

Herbert, L. S., Lovett, D. A., and Radford, R. D.* (1978). Evaporative weight loss during meat chilling. *Food Technol. Aust.* **30**, 145–8.

Lovett, D. A., Herbert, L. S., and Radford, R. D.* (1978). Carcass chilling — experimental investigation of weight loss from lean meat. *Int. J. Refrig.* **1**, 33–7.

Macfarlane, J. J., Schmidt, G. R.,* and Turner, R. H. (1977). Binding of meat pieces: a comparison of myosin, actomyosin and sarcoplasmic proteins as binding agents. *J. Food Sci.* **42**, 1603–5.

Shay, B. J., Grau, F. H., Ford, A. L., Egan, A. F., and Ratcliff, D.* (1978). Microbiological quality and storage life of sliced vacuum-packed smallgoods. *Food Technol. Aust.* **30**, 48–54.

Walker, D. J., Harris, P. V., and Shaw, F. D. (1977). Accelerated processing of beef. *Food Technol. Aust.* **29**, 504–7.

Williams, S. C. (1978). Hot-boning. *Food Technol. Aust.* **30**, 495–7.

*Not a member of the Division.